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Effects of Palm Oil Biodiesel Blends on the Emissions of Oil Burner

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Abstract. Biodiesel is one of the alternative fuels used in oil burner. In order to determine the quality of this biodiesel produced at UTHM Biodiesel Pilot Plant, it is tested in crucible furnace system. This study is focused on the effects of biodiesel on emissions from an oil burner. It uses 5 % (B5), 10 % (B10) and 15 % (B15) biodiesel blended with diesel. 100 % diesel is used as a comparison. Emissions from the combustion of diesel burner were measured using gas analyzer and smoke detector. Measured parameters were carbon monoxide (CO), hydrocarbon (HC), carbon dioxide (CO_2) and opacity. Results show a significant improvement up to 87 % of harmful emissions showed by blended fuel compared to 100 % diesel. The overall results indicate the potential of palm oil biodiesel blend in reducing harmful emissions from the burner system.

Introduction

Particular attention has been given on the development of alternative fuels, especially with reference to the biodiesel. The use of biodiesel blended with diesel on the diesel engine has been the subject of research since 1980s. Biodiesel is a liquid fuel made up of fatty acid alkyl esters, fatty acid methyl esters, or long-chain mono alkyl esters. Like petroleum diesel, biodiesel is used to fuel compression-ignition engines, which run on petroleum diesel. Biodiesel is a domestically produced, renewable fuel that can be manufactured from vegetable oils, animal fats, or recycled restaurant grease. It is a cleaner-burning replacement for petroleum diesel fuel. It is nontoxic and biodegradable.

Song et al. [1] focused on the ethanol-diesel blended fuels effects on the emissions and particulate extracts. Several blends from 0 to 5, 10, 15 and 20 % were prepared and tested on the diesel engine. It was found that the introduction of ethanol could result on higher brake specific total hydrocarbon (THC) and carbon monoxide (CO) emissions but lower smoke emissions. Power output of the diesel engine was also decreased due to the lower energy content reduction by approximately 2 % for each 5 % of the ethanol addition. Lapuerta et al. [2] compiled various published work involved biodiesel fuels and its relation to diesel engine emissions. It was agreed that in most work, there was an increase in fuel consumption due to the loss of heating value. The most advantage of biodiesel was in significant reduction of particulate emission compared to other emissions.

Another study was conducted on the usage of low sulphur gaseous hydrocarbons i.e. liquid butane in industrial application. It was tested on a dual pumping and injection system at varying pressure. Flame and emission characteristics were observed and it was found that temperatures and NO_x concentrations are lower than diesel fuel. This indicates high potential usage of this fuel in diesel system [3]. Many researchers worked on liquid burner system tested biodiesel and compared with gas oil [4,5] and diesel [6]. Results showed improved emissions for CO, CO_2, particulate matters while an increase in NO_x emission. Temperature of exhaust gas was also increased significantly which showed high potential of biodiesel application in oil burner system especially in fulfilling industrial needs.

In this paper, oil burner used for aluminium alloy melting facilities was tested using four types of fuels: 5, 10 and 15 % of biodiesel was added to the diesel fuel (B5, B10 and B15) and 100 % commercial diesel. Pollutant emission i.e. HC, CO_2, CO and opacity were measured at different fuel flow rate from 48 to 54 ml/min. Comparison of these parameters was done on the operation of oil burner using commercial diesel fuel. The rest of the paper is organized as follows; experimental setup and fuels are outlined in methodology section. Results and discussion section elaborates the results obtained and its impact on the pollutant emission which can be related to the actual application of oil burner.

Methodology

Experimental set up was conducted on the crucible furnace facility in Fig. 1 using low pressure air atomizing liquid fuel burner from Stinchcombe Furnaces. Fuel consumption of this burner ranges from 4.5 to 31.5 liter per hour while oil pressure range is between 1.40 to 2.10 kg/cm^2. Fig. 2 represents the layout of oil burner, tank 1 and tank 2 (tank 1 consists of diesel; tank 2 consists of blended biofuel). Air was supplied from the blower of Fans and Blowers Limited which is connected directly to oil burner at constant flow rate. Fuel delivery from each tank was supplied under gravity pressure to fuel injector controlled using a control knob of oil burner. Fuel flow rate was measured using 500 ml buret with 150 ml of fuel consumed at measured time. Gas analyzer AutoCheck was used to measure HC, CO and CO_2 whereas opacity was measured using smoke meter. Gas probe was inserted through a hole at chimney section located 1000 mm from the ground. Exhaust gas temperature was measured at approximately 1200 mm from fuel injector using K-type thermocouple with digital meter reader.

Fig. 1 Crucible furnace facility.

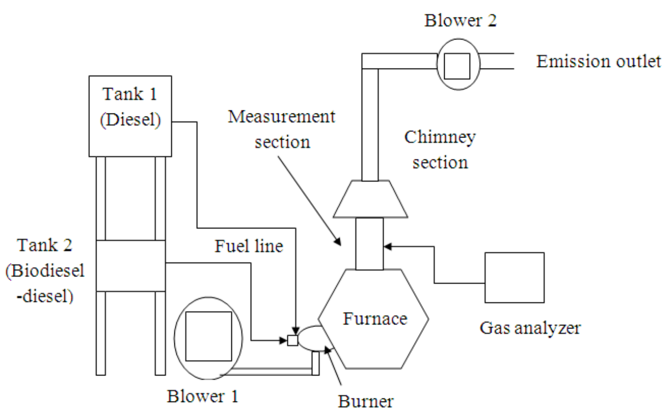

Fig. 2 Experimental set up of oil burner system.

Commercial diesel was purchased from the market while biodiesel was produced from palm oil processed at UTHM Biodiesel Pilot Plant Facility. Blended fuel was produced using blending machine which mixes biodiesel and diesel at certain percentage with constant temperature at 60 ^oC. B5 represents 5 % of biodiesel with 95 % of commercial diesel. The next section elaborates trends of emission against flow rate for B5, B10 and B15 before being compared to commercial diesel.

Results and Discussion

Effectiveness of biodiesel blended fuel on reducing the emissions from the combustion of the burner is compared to the diesel fuel. Fig. 3 shows the concentration of HC, CO, CO_2 and opacity against flow rate at different fuel configuration. Using diesel as a fuel, HC emission is observed at flow rate from 48.6 to 50.5 ml/min. It is found that HC increases as the flow rate increases. The critical point occurs at 49.9 to 50.5 ml/min where HC increases double from 20 to 40 ppm. However, introducing biodiesel in the burner system has reduced sharply HC emission which varies from 4 to 7 ppm; 80 to 82.5 % of improvement. It is observed that the diluted sprays of fuel due to the presence of biofuel affects the flame characteristic and produces lower HC emission [8]. This is due to the formation of homogeneous flame which produces less HC as the biodiesel in the fuel also helps to increase oxidation and reduces HC formation. Similar trend is observed for CO_2 emission for diesel and blended biodiesel. As the flow rate increases, amount of CO_2 also increases from 4 to 24 % for 48.6 to 50.5 ml/min flow rate. Significant reduction of CO_2 emission up to 87 % is observed for B5, B10 and B15 usage in burner system. The readings range from 2.3 to 3.2 % for 50.3 to 51.6 ml/min highlights the ability of biodiesel in reducing CO_2 emission from the burner. The availability of oxygen in the biodiesel reduces fuel carbon content [7] which also contributes to the reduction of CO_2.

Observation on CO emission produces similar trend with HC and CO_2. For diesel at 50.5 ml/min, it produces high emission up to 0.84 % of CO. Introducing biodiesel has managed to reduce CO only up to 0.01 % at 48.5 to 54.1 ml/min. In terms of combustion, higher flow rate produces dense spray of volatile fuels which prevents the entrance of unnecessary oxygen to form a flammable mixture in the spray central region. The flame is formed in the peripheral region where enough oxygen is available. These flames are homogeneous and similar to the flames of gaseous fuel which produces less emission [8]. CO concentration level decreases due to presence of sufficient oxygen in the biodiesel which helps the oxidation process in the combustion and able to reduce CO emission up to 90 % compared to diesel fuel. It is in agreement with the properties of the typical biodiesel blended fuel indicated a reduction of 2 % in heat value and 3.9 % increment in oxygen content for 10 % ethanol in diesel [9]. Measurement of opacity shows the presence of biodiesel increases the amount of opacity compared to diesel.

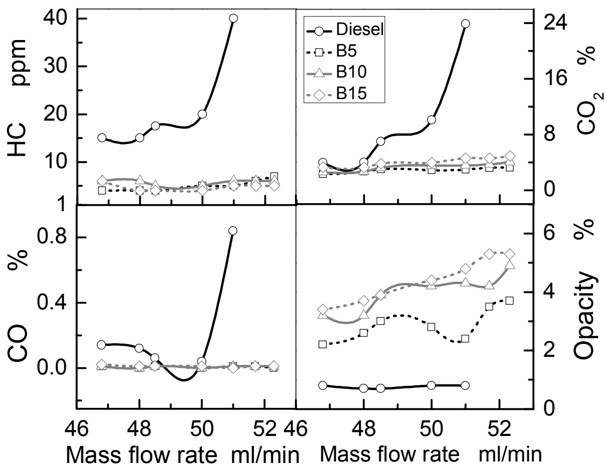

Fig.3. Emission trends of HC, CO_2, CO and opacity at different flow rate.

Conclusion

The usage of biodiesel blends in diesel has shown significant reduction of HC, CO_2 and CO emissions up to 87 % as compared to the diesel fuel. Overall result also depicts B5 produces the lowest emission compared to B10 and B15.

Acknowledgement

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